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Issued March 7, 1912.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE.
HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

PAPER PULPS FROM VARIOUS FOREST WOODS.

EXPERIMENTAL DATA AND SPECIMENS OF SODA AND SULPHITE PULPS.

COMPILED BY

HENRY E. SURFACE,

Chemical Engineer in Forest Products.

WASHINGTON:
1912.

UNITED STATES OF AMERICA
GOVERNMENT PRINTING OFFICE

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., December 4, 1911.

SIR: I have the honor to transmit herewith a manuscript entitled "Paper Pulps from Various Forest Woods," compiled by Henry E. Surface, chemical engineer in forest products, and to recommend its publication.

Respectfully,

HENRY S. GRAVES,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Purpose of the experiments	7
Preparation of the pulps	8
Raw materials tested	10
Experimental data	11
Index to pulp specimens	28

PAPER PULPS FROM VARIOUS FOREST WOODS.

PURPOSE OF THE EXPERIMENTS.

The purpose of this report is to show specimens of paper pulps made from a number of different woods, and to give the experimental data connected with their production. These specimens will indicate the possibilities for pulp of certain woods, of which some have been used commercially to a slight extent, and others not at all. The results are presented for the consideration of the paper trades and those interested in the pulp and paper industries.

It is not within the scope of this report to recommend for general commercial use any given wood or woods; further investigation is required before their availability and suitability for pulp making can be shown definitely. The report does show, however, the yields, qualities, and general characters of the pulps, and the cooking conditions used to obtain these results. While they are not sufficiently complete for final conclusions, they mark an important step, and even without further experimentation it is assured that a number of the woods can be used advantageously in commercial practice, under suitable conditions.

The tests on which this publication is based were made at the following pulp and paper laboratories of the Forest Service: South Boston, Mass., Pulp Laboratory, 1906–7, Dr. H. S. Bristol, in charge; Washington Laboratory, 1907–1909, Mr. E. Sutermeister, in charge of pulp investigations; and the Forest Products Laboratory (in cooperation with the University of Wisconsin), Madison, Wis., 1910–11, Mr. H. E. Surface, in charge of the section of pulp and paper. Some of the pulps in question were made at each of the laboratories mentioned. Their final collection and running into sheets, however, was made at the Forest Products Laboratory.

PREPARATION OF THE PULPS.

The various woods were received in the form of logs, which were barked and cut into chips. These chips were then cooked with live steam in 65-gallon digesters, using caustic soda solutions and calcium and magnesium bisulphite solutions as cooking liquors for the soda and sulphite "cooks," respectively. After any given wood was cooked into a pulp the digester containing it was "blown" and the pulp was washed with water in a blow pit. The washed pulp was then screened by means of a flat-plate diaphragm screen. The unbleached pulps from which the natural color specimens were obtained were then passed through a diaphragm "machine screen" having 0.009-inch slots, and run out on a 16-inch Fourdrinier paper machine into continuous

sheets 10 inches wide. The unbleached pulps from which the bleached specimens were obtained were treated with bleaching powder solutions in a 25-pound Emerson beating engine, after which they were screened and run out on the paper machine as with the natural color pulps. No additional fibers, fillers, or coloring materials were added to any of the pulps, which represent only the natural fibers from the various woods.

It may be noted that some of the pulps contain numerous dirt specks. These are not derived from the woods used, but are due to unavoidable defects in the small-size apparatus employed. In commercial work using the same woods and cooking treatments, these would be eliminated. For this reason they should not be considered as detrimental to the quality of the pulps. The color of the bleached pulps is also in some cases much poorer than would be the case if the water used in making up the bleached pulp sheets had been of better quality. This is another factor that could not be eliminated under the conditions existing at the time of making the runs. Another feature, which properly should be mentioned, is that the specimens were in general made up from a mixture of pulps from several different cooks of the same species of wood. This was necessary because the quantity of pulp from one cook was in several instances insufficient for making a specimen in the amount required. Pulps from poorer cooks, therefore, had to be mixed with pulps from better ones, and this resulted in specimens which are not ade-

quately representative of the best pulps which could be obtained.

RAW MATERIALS TESTED.

Table 1 shows the raw materials used in the tests and the localities from which they were obtained. The shipment number, originally used as a mark of identification, is here used for reference to Tables 2 and 3, which contain the records of the experimental treatments.

TABLE 1.—*Species used in the experiments, and their sources.*

Common name.	Botanical name.	Shipment No.	Where grown.
Aspen	Populus tremuloides, Michx.	L–19	Wisconsin.
Bald cypress	Taxodium distichum, Rich.	S–3	Louisiana.
Beech	Fagus atropunicea, Sudw.	S–7	Pennsylvania.
Cotton gum	Nyssa aquatica, Linn.	S–2	Louisiana.
Do	do	S–4	Alabama.
Douglas fir	Pseudotsuga taxifolia, Britt.	S–498	Oregon.
Engelmann spruce	Picea engelmanni, Engelm.	S–502	Colorado.
Grand fir	Abies grandis, Lindl.	S–39	Washington.
Hemlock	Tsuga canadensis, Carr.	S–8	Pennsylvania.
Incense cedar	Libocedrus decurrens, Torr.	S–36	California.
Jack pine	Pinus divaricata, Du Mont de Cours.	L–26B	Wisconsin.
Do	do	L–105	Do.
Loblolly pine	Pinus tæda, Linn	S–33	South Carolina
Do	do	S–5	Virginia.
Do	do	L–2	Louisiana.
Lodgepole pine	Pinus contorta murrayana, Sudw.	S–32	Wyoming.
Do	do	S–469	Do.
Do	do	S–499	Montana.
Longleaf pine	Pinus palustris, Mill.	L–3	Mississippi.
Red alder	Alnus oregona, Nut.	S–524	Oregon.
Red maple	Acer rubrum, Linn.	S–14	Maryland.
Red spruce	Picea rubens, Sarg.	S–11	New Hampshire.
Scrub pine	Pinus virginiana, Mill.	S–19	Maryland.
Do	do	S–20	Do.
Do	do	S–21	Virginia.
Sycamore	Platanus occidentalis, Linn.	S–18	Maryland.
Tamarack	Larix laricina, Koch	L–26E	Wisconsin.
Tulip tree	Liriodendron tulipifera, Linn.	S–16	Maryland.
Western hemlock	Tsuga heterophylla, Sarg.	S–38	Washington.
White fir	Abies concolor, Parry	S–35	California.
Do	do	S–37	Do.

EXPERIMENTAL DATA.

Tables 2 and 3 show the cooking conditions used in the preparation of the several pulps and the results that were obtained by determinations of yields and qualities. With a few unimportant exceptions the data for the several cooks are comparable with one another. In examining these data it should be kept in mind that commercial practice was followed so far as possible, but the experimental conditions did not permit this in all features of the tests.

The various headings in the tables may be explained as follows:

Chip charge, bone-dry weight.—The quantity of the wood with which the digester is charged for each cook is calculated to the bone-dry-weight basis by means of a moisture sample.

Water in chips.—The amount of water in the wood at the time the digester is charged is expressed in percentage of water, based on the calculated bone-dry weight of the chips.

Concentrations of cooking liquor at start of cook.—The concentrations of the various constituents of the cooking liquors are based on analyses of such liquors as charged into the digester. The sulphur dioxide (SO_2) concentrations can be reduced to the "sulphite-mill per cent basis" by dividing the number of grams per liter by 10. The "combined SO_2" represents the amount of sulphur dioxide theoretically combined with

the lime oxides in the cooking liquors to form the normal sulphites. The "free" or "available SO_2" represents the amount of the sulphur dioxide in the cooking liquors which is not "combined SO_2." The magnesium oxide (MgO) and calcium oxide (CaO) values are calculated from analyses of the limes used and from the "combined SO_2" values. The total sodium oxide (Na_2O) is calculated from the concentrations of caustic soda (NaOH) and sodium carbonate (Na_2CO_3) each reduced to the Na_2O basis.

Causticity of cooking liquors at start of cook.—The causticity represents the ratio, expressed as a percentage, of the sodium oxide in the caustic soda, as such, to the total sodium oxide in the cooking liquors at the beginning of the cook.

Quantity of cooking liquors per pound of chips.—The quantities of the various constituents are based on unit bone-dry weight of the chips charged and on the liquor charge at the beginning of the cook. The values for the "S" (sulphur) items multiplied by 2 will give percentages of "SO_2."

Duration of cooking.—The total period begins with the turning on of steam into the digester and ends with the "blowing" of the cook. The period at zero gauge pressure occurs at the beginning of the cook and ends when the needle of the digester gauge leaves the zero point. The period at maximum gauge pressure occurs during the final stages of the cooking, when the digester pressure is held constant at a given maximum value by

means of a relief valve. If desired, the gauge pressures for the soda cooks may be converted directly to temperatures by means of pressure-temperature tables for saturated steam. The period below zero steam pressure is at the beginning of the cook, when the digester temperature is below 100° C. (212° F.). The period at maximum steam pressure (temperature) occurs during the final stages of cooking, when the temperature of the digester contents is held at a constant maximum. Temperatures have been converted into steam pressures by means of the pressure-temperature tables.

Yields.—The proportion of yields, expressed as percentages, are based on the bone-dry weights of the products indicated and the bone-dry weight of the chips. Screened pulp represents such pulp in the unbleached state. Screenings represent the material removed by means of a diaphragm screen.

Quality of pulps.—All percentages of quality are based on the bone-dry weight of the screened unbleached pulps tested. Cellulose was determined by the Cross and Bevan method. The percentage of bleach required represents the number of parts of bleaching powder (35 per cent available chlorine) required to bleach 100 parts of the screened unbleached pulp to the commercial white color.

TABLE 2.—*Record of experimental cooks using the sulphite process.*

Species.	Shipment number.	Cook number.	Chip charge, bone-dry weight.	Water in chips.	Cooking liquor charge at start of cook.				
					Concentrations.				
					Total SO_2.	Combined SO_2.	Free SO_2.	Combined MgO.	Combined CaO.
			Pounds.	*Per cent.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*
Bald cypress	S-3	1	36.7	9.1	43.8	15.4	28.4	.....	.....
		2	40.5	11.1	43.4	15.0	28.4	.....	.....
		3	29.6	18.2	42.6	14.3	28.3	.....	.....
Cotton gum	S-2	1	34.8	14.9	42.2	14.1	28.1	.....	.....
		2	39.8	13.1	43.1	14.7	28.4	.....	.....
		3	22.3	12.2	42.8	14.2	28.6	.....	.....
		4	22.7	10.2	42.8	14.3	28.5	.....	.....
Douglas fir	S-498	1	16.0	56.4	41.0	10.3	30.7	2.7	5.3
		2	17.0	47.2	38.5	10.4	28.1	2.7	5.4
Engelmann spruce	S-502	1	13.9	79.9	41.5	10.8	30.7	2.8	5.6
		2	14.0	78.1	41.3	10.8	30.5	2.8	5.6
		3	13.7	118.4	41.5	10.8	30.7	2.8	5.6
		4	12.7	96.3	41.2	10.5	30.7	2.7	5.4
		5	10.9	128.8	40.7	11.0	29.7	2.9	5.7
		6	18.7	33.6	40.0	10.3	29.5	2.7	5.3
		12	17.0	47.1	39.5	11.7	27.8	3.0	6.0
Grand fir	S-39	1	14.6	71.8	41.0	11.0	30.0	2.9	5.7
		2	15.4	62.6	41.0	12.2	28.8	3.2	6.3
		3	16.9	47.7	41.5	10.8	30.7	2.8	5.6
		4	18.8	33.3	40.5	10.8	29.7	2.8	5.6
		5	21.3	17.5	36.1	12.7	23.4	3.3	6.5
Hemlock	S-8	1	36.4	9.9	43.3	14.8	28.5	.....	.....
		2	36.1	10.8	42.5	13.4	29.1	.....	.....

		2	15.5	28.9	40.0	9.6	30.4	2.5	4.9
		3	16.7	19.5	38.7	9.7	29.0	2.5	5.0
Jack pine	L–26B	6	13.9	80.4	41.0	11.5	29.5	3.7	5.0
		7	14.6	70.8	40.0	11.5	28.5	3.7	5.0
		8	13.7	82.0	40.0	11.0	29.0	3.5	4.7
		9	14.8	78.6	45.3	15.0	30.3	4.8	6.5
		1	29.5	18.6	41.0	11.5	29.5	.....	.....
Loblolly pine	S–5	3	42.0	13.1	43.8	15.2	28.6	.....	.....
	S–33	1	15.8	58.2	43.2	14.3	28.9	.....	.....
		2	19.2	30.2	42.2	13.9	28.3	.....	.....
		3	19.2	30.2	42.6	14.2	28.4	.....	.....
		1	15.1	66.1	41.0	9.6	31.4	2.5	4.9
		2	15.2	64.7	39.8	9.6	30.2	2.5	4.9
		3	15.8	57.8	40.6	12.9	27.7	3.3	6.6
Lodgepole pine	S–499	6	17.3	44.3	39.5	10.7	28.8	2.8	5.5
		7	17.1	45.9	40.0	14.1	25.9	3.7	7.3
		8	19.4	28.7	40.7	11.5	29.2	3.0	5.9
		9	20.2	23.8	34.7	12.8	22.4	3.2	6.3
		2	30.0	16.7	40.0	12.3	27.9	.....	.....
		3	28.9	21.1	42.2	11.7	30.5	.....	.....
Red spruce	S–11	4	29.2	19.8	42.9	15.9	27.0	.....	.....
		5	17.2	16.3	38.5	10.0	28.5	.....	.....
Scrub pine	S–19, 21	1	30.3	15.5	43.3	15.2	28.1	.....	.....
		2	35.0	14.3	42.5	15.2	27.3	.....	.....
		3	37.3	11.9	43.5	15.1	28.4	.....	.....
		14	23.2	7.6	49.0	18.5	30.5	5.9	8.0
		15	23.2	7.7	50.0	19.0	31.0	6.1	8.2
Tamarack	L–26E	16	23.2	7.7	49.0	19.0	30.0	6.1	8.2
		17	23.2	7.7	51.0	19.5	31.5	6.2	8.4
		1	15.4	29.9	36.9	9.6	27.3	1.0	7.0
		2	19.0	58.0	38.7	9.2	29.5	2.4	4.7
		3	18.3	36.5	40.0	9.6	30.4	2.5	4.9
Western hemlock	S–38	4	45.3	32.5	40.7	11.3	29.4	2.9	5.8
		5	46.7	28.5	38.0	10.2	27.8	2.6	5.3
		1	16.0	24.7	37.0	8.5	28.5	2.2	4.4
		2	16.1	24.1	40.0	9.6	30.4	2.5	4.9
White fir	S–35	1	12.6	58.8	43.0	10.0	33.0	2.6	5.1
	S–35, 37	4	25.4	57.3	36.3	8.3	28.0	2.2	4.3
		5	26.8	49.1	41.1	8.7	32.4	2.3	4.5
		8	48.9	22.7	40.1	9.6	30.5	2.5	4.9

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TABLE 2.—*Record of experimental cooks using the sulphite process*—Continued.

Species.	Shipment number.	Cook number.	Cooking liquor charge at start of cook. Quantity per pound of chips, bone-dry weight. Total liquor.	Total S.	Combined S.	Free S.	Combined MgO.	Combined CaO.
			Gallons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bald cypress	S-3	1	1.09	19.9	7.0	12.9	.....	.....
		2	.99	17.9	6.2	11.7	.....	.....
		3	1.52	27.1	9.1	18.0	.....	.....
Cotton gum	S-2	1	1.15	20.2	6.7	13.5	.....	.....
		2	1.01	18.2	6.2	12.0	.....	.....
		3	2.02	36.1	12.0	24.1	.....	.....
		4	1.98	35.4	11.8	23.6	.....	.....
Douglas fir	S-498	1	2.82	48.2	12.1	36.1	6.3	12.5
		2	2.65	42.6	11.5	31.1	6.0	11.8
Engelmann spruce	S-502	1	3.24	56.1	14.6	41.5	7.6	15.0
		2	3.20	55.2	14.4	40.8	7.5	14.9
		3	3.28	56.7	14.7	42.0	7.7	15.2
		4	3.53	60.7	15.5	45.2	8.1	15.9
		5	4.11	69.9	18.9	51.0	9.8	19.5
		6	2.41	40.2	10.6	29.6	5.4	10.6
		12	2.65	43.6	12.9	30.7	6.8	13.3
Grand fir	S-39	1	3.09	52.9	14.2	38.7	7.4	14.6
		2	2.92	50.1	14.9	35.2	7.8	15.4
		3	2.66	46.0	12.0	34.0	6.2	12.3
		4	2.40	40.5	10.8	29.7	5.6	11.1
		5	2.11	31.9	11.2	20.7	5.8	11.6
Hemlock	S-8	1	1.10	19.9	6.8	13.1	.....	.....
		2	1.24	22.1	7.0	15.1	.....	.....
Incense cedar	S-36	1	3.13	47.3	12.0	35.3	6.1	12.1
		2	2.90	48.4	11.6	36.8	6.0	12.0

Jack pine	L–26B	3	2.69	43.4	10.9	32.6	5.7	11.2
		6	2.89	49.3	13.9	35.5	8.9	11.9
		7	2.73	45.7	13.1	32.6	8.4	11.3
		8	2.91	48.7	13.4	35.3	8.6	11.6
		9	2.70	51.2	16.9	34.2	10.8	14.6
Loblolly pine	S–5	1	1.35	23.1	6.5	16.6	.....	.....
		3	.95	17.4	6.0	11.4	.....	.....
	S–33	1	2.85	51.4	17.1	34.2	.....	.....
		2	2.34	41.3	13.6	27.7	.....	.....
		3	2.34	41.7	13.9	27.8	.....	.....
Lodgepole pine	S–499	1	2.99	51.2	12.0	39.2	6.2	12.3
		2	2.96	49.2	11.9	37.3	6.2	12.2
		3	2.84	48.1	15.3	32.8	7.9	15.8
		6	2.60	42.8	11.6	31.2	6.0	12.0
		7	2.63	43.9	15.5	28.4	8.0	15.9
		8	2.32	39.4	11.1	28.3	5.8	11.5
		9	2.23	32.2	11.4	20.8	5.9	11.8
Red spruce	S–11	2	1.33	22.5	7.0	15.5	.....	.....
		3	1.38	24.4	6.7	17.7	.....	.....
		4	1.37	24.5	9.1	15.5	.....	.....
		5	2.62	42.2	11.0	31.2	.....	.....
Scrub pine	S–19, 21	1	1.32	23.9	8.4	15.5	.....	.....
		2	1.14	20.2	7.2	13.0	.....	.....
		3	1.21	22.0	7.6	14.4	.....	.....
Tamarack	L–26E	14	1.72	35.2	13.3	21.9	8.5	11.4
		15	1.72	35.9	13.6	22.3	8.7	11.7
		16	1.72	35.2	13.6	21.5	8.7	11.7
		17	1.72	36.6	14.0	22.6	8.9	12.1
Western hemlock	S–38	1	2.92	45.0	11.7	33.3	2.4	17.1
		2	2.11	34.0	8.0	26.0	4.2	8.3
		3	2.45	41.0	9.8	31.2	5.1	10.2
		4	.66	11.2	3.1	8.1	1.6	3.2
		5	.94	14.9	4.0	10.9	2.1	4.1
White fir	S–35	1	2.81	43.3	9.9	33.4	5.2	10.2
		2	2.79	46.6	11.2	35.4	5.8	11.5
	S–35, 37	1	2.78	49.8	11.6	38.2	6.1	11.9
		4	1.77	26.8	6.2	20.6	3.2	6.3
		5	1.68	28.7	6.1	22.6	3.2	6.3
		8	.61	10.2	2.4	7.8	1.3	2.5

TABLE 2.—*Record of experimental cooks using the sulphite process*—Continued.

Species.	Shipment number.	Cook number.	Duration of cooking.					Maximum pressures.	
			Total.	At zero gauge pressure.	At maximum gauge pressure.	Below zero steam pressure.	At maximum steam pressure.	Gauge.	Steam.
			Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*
Bald cypress	S-3	1	8.0	0.0	4.0	2.0	2.7	85	58
		2	10.0	.0	3.8	2.0	3.8	88	60
		3	11.0	.0	6.0	3.0	4.7	90	60
Cotton gum	S-2	1	8.0	.0	3.0	2.0	3.0	85	60
		2	7.5	.0	2.5	1.2	1.8	84	58
		3	9.0	.0	5.5	3.5	4.0	80	56
		4	9.0	.0	4.0	3.0	4.0	86	56
Douglas fir	S-498	1	8.0	.3	4.5	3.0	2.0	80	60
		2	9.0	.3	5.5	3.3	3.0	80	60
Engelmann spruce	S-502	1	10.0	.3	4.3	3.0	3.0	90	70
		2	10.0	.3	4.0	3.0	3.0	90	70
		3	9.0	.3	4.5	3.0	3.0	80	60
		4	10.0	.3	4.3	3.0	3.0	90	70
		5	10.0	.3	5.5	2.8	4.0	80	60
		6	10.0	.3	4.5	3.3	2.8	90	70
		12	10.0	.3	5.8	3.3	4.0	80	60
Grand fir	S-39	1	8.0	.3	4.0	3.0	2.0	80	60
		2	9.0	.3	3.0	3.5	2.0	80	60
		3	9.0	.3	4.0	3.0	2.0	80	60
		4	9.0	.3	5.0	3.0	3.0	80	60
		5	8.0	.3	4.0	3.0	2.0	80	60
Hemlock	S-8	1	8.5	.0	4.0	1.7	3.0	86	59
		2	9.0	.0	4.0	3.0	2.0	85	60
Incense cedar	S-36	1	8.0	.3	4.0	2.8	2.0	80	60
		2	9.8	.3	3.8	3.0	2.5	88	64
		3	12.5	.3	4.5	3.0	4.0	90	68

Jack pine	L-26B	6	10.0	.8	6.2	3.0	3.2	80	46
		7	10.0	.2	5.8	3.0	3.2	80	46
		8	15.0	.2	12.2	3.0	4.8	73	46
		9	15.0	.2	8.8	3.0	5.0	75	46
Loblolly pine	S-5	1	10.0	.0	2.0	2.7	.1	80	60
		3	8.0	.0	3.0	2.0	2.0	85	60
	S-33	1	10.0	.0	4.5	2.0	4.3	85	60
		2	10.0	.0	5.5	3.0	4.0	85	60
		3	11.0	.0	6.0	2.7	5.3	85	60
Lodgepole pine	S-499	1	8.0	.3	3.8	2.0	2.0	80	60
		2	9.0	.3	3.5	3.0	2.0	90	70
		3	12.0	.3	5.8	3.0	3.0	80	60
		6	10.0	.3	5.3	3.0	3.0	90	70
		7	9.0	.3	4.5	2.5	2.8	80	60
		8	11.0	.3	6.3	3.0	3.0	90	62
		9	12.5	.3	8.8	3.3	1.5	90	60
Red spruce	S-11	2	10.0	.0	7.0	2.5	.1	70–80	50
		3	10.0	.0	7.0	3.0	.1	70–80	60
		4	8.5	.0	4.0	3.0	2.0	85	60
		5	8.0	.0	4.0	3.0	2.0	80	60
Scrub pine	S-19, 21	1	7.7	.0	3.0	3.0	2.5	84	60
		2	9.0	.0	3.0	1.0	3.0	85	59
		3	9.7	.0	4.5	2.3	3.5	90	60
Tamarack	L-26E	14	10.0	.2	5.5	4.5	3.0	80	46
		15	16.0	1.0	9.0	5.0	4.0	80	46
		16	16.0	1.3	9.5	5.0	5.0	80	46
		17	20.0	.8	12.5	5.0	9.0	80	38
Western hemlock	S-38	1	8.0	.3	4.0	1.5	2.0	80	60
		2	10.0	.3	5.0	3.0	2.0	80	60
		3	9.0	.3	4.0	3.0	2.0	80	60
		4	9.0	.3	3.0	3.0	2.0	80	60
		5	9.0	.3	4.0	3.0	2.0	80	60
White fir	S-35	1	9.0	.3	5.3	1.8	4.0	80	60
		2	8.8	.3	4.0	2.6	2.8	80	62
	S-35, 37	1	8.0	.3	8.3	2.5	1.5	80	60
		4	8.8	.3	5.5	2.3	4.0	80	60
		5	8.8	.3	4.7	2.8	3.0	80	54–68
		8	9.0	.3	4.5	3.3	2.0	80	60

TABLE 2.—*Record of experimental cooks using the sulphite process*—Continued.

Species.	Shipment number.	Cook number.	Yields.		Quality of pulps.			
			Screened pulp.	Screenings.	Ash.	Cellulose.	Bleach required.	Loss on bleaching.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bald cypress	S-3	1	43.5	[1] 3.9	1.18	72.0	.....	.....
		2	46.9	[1] 2.4	.68	75.6	126.0	12.9
		3	.....	[1] .5	.52	81.5	52.0	3.8
Cotton gum	S-2	1	43.0	[1] 1.8	.99	83.5	35.0	4.6
		2	42.6	[1] .3	.78	83.6	17.0	2.1
		3	44.5	[1] .9	1.13	81.5	20.5	3.3
		4	43.5	[1] .4	.99	82.7	35.0	5.2
Douglas fir	S-498	1	38.8	16.0	1.25	.....	70.0	11.9
		2	32.9	25.8	.....	.....	.....	.....
Engelmann spruce	S-502	1	34.7	1.9	.89	86.7	15.0	2.9
		2	39.0	.3	.75	87.2	13.5	2.5
		3	45.2	1.2	.89	85.7	22.5	5.1
		4	45.7	.5	1.12	87.7	12.0	2.4
		5	52.5	.5	.98	88.0	12.3	2.2
		6	40.0	.3	.86	85.9	12.5	2.3
		12	40.1	.5	1.35	85.6	21.0	5.1
Grand fir	S-39	1	51.4	1.7	1.71	.....	80.0	12.8
		2	24.1	19.4	2.00	72.8	.....	.....
		3	46.0	.6	.76	.....	26.6	1.6
		4	46.9	1.5	.86	.....	28.0	5.7
		5	46.4	2.4	2.78	.....	40.0	7.8
Hemlock	S-8	1	43.8	[1] 1.5	.75	81.2	85.0	10.0
		2	39.2	[1] 3.7	.38	85.8	37.0	4.9
Incense cedar	S-36	1	40.8	8.3	2.37	71.3	.....	.....
		2	37.9	1.3	1.38	78.6	.....	.....
		3	16.3	.4	1.35	80.8	.....	.....
Jack pine	L-26B	6	45.5	4.9	.....	.....	.....	.....
		7	34.8	17.2	.....	.....	.....	.....

		8	40.7	5.9				
		9	53.2	3.0				
Loblolly pine	S–5	1		[1].3	.83	85.4	35.0	7.7
		3		[1]2.1	.57	83.1	39.0	5.7
	S–33	1			4.50			
		2			1.06	76.6	72.0	9.3
		3			1.45		80.0	12.9
Lodgepole pine	S–499	1	43.6	7.6	1.15	80.3	50.0	8.8
		2	43.1	2.4	1.29	81.6	39.0	7.0
		3	39.9	3.1	2.53	81.2	29.0	6.6
		6	36.8	.5	.60	78.5	22.8	3.8
		7	50.9	5.3	6.84	75.5	43.0	13.7
		8	32.4	5.7	.65		23.0	3.6
		9	33.5	.3	.44		16.8	2.5
Red spruce	S–11	2						
		3		[1]8.2	1.96	73.5	98.0	22.0
		4		[1].7	.67	86.1	17.0	3.6
		5	53.9	1.7	2.00	84.4	35.0	6.3
Scrub pine	S–19, 21	1		[1]6.7	1.13		65.0	9.5
		2		[1]3.1	.59		67.0	7.0
		3		[1]1.1	.43		20.4	4.1
Tamarack	L–26E	14	42.8	8.4				
		15	46.0	.8				
		16	45.8	1.5				
		17	46.7	1.7				
Western hemlock	S–38	1	43.6	.8	2.41	85.1	44.8	7.7
		2	45.2	2.5	1.29	83.1	41.0	7.6
		3	47.3	1.1	1.13	84.7	35.0	6.4
		4	28.6	18.1	1.24	80.3	72.0	11.7
		5	42.0	.3	.66	85.9	25.0	4.5
White fir	S–35	1	40.6	1.3	1.03	85.8	20.5	4.0
		2	42.7	.9	1.22	85.1	23.5	4.7
	S–35, 37	1	45.5	.2	1.23	85.6	28.0	4.9
		4	48.3	.8	.66	88.0	19.0	1.8
		5	44.8	.4	.90	83.8	17.0	3.2
		8	41.4	.7	.43	86.0	12.8	1.1

[1] Air-dry screenings. Percentage based on bone-dry weight of chips.

TABLE 3.—*Record of experimental cooks using the soda process.*

Species.	Shipment number.	Cook number.	Chip charge, bone-dry weight.	Water in chips.	Cooking liquors at start of cook.			
					Concentrations.			Causticity.
					NaOH.	Na_2CO_3.	Total Na_2O.	
			Pounds.	*Per cent.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*	*Per cent.*
Aspen	L-19	2	39.4	9.1	80.5	2.2	63.7	97.9
		4	40.3	8.2	80.2	3.1	64.0	97.1
		7	39.9	9.8	71.6	2.7	57.1	97.2
		25	39.0	8.2	70.0	2.1	55.5	97.8
Beech	S-7	5	21.8	14.6	91.0	5.2	73.5	95.9
		6	22.1	13.0	90.0	6.4	73.5	94.9
		7	22.1	13.3	90.0	4.6	72.5	96.2
		8	21.9	14.2	100.0	5.8	80.9	95.8
Cotton gum	S-4	3	22.4	11.8	90.0	5.1	72.7	95.9
		4	22.1	13.0	90.0	8.1	74.5	93.6
Douglas fir	S-498	1	40.4	9.1	90.0	2.7	71.4	97.8
		2	40.4	9.1	90.0	2.4	71.2	98.0
Engelmann spruce	S-502	4	21.4	16.9	90.0	5.0	72.7	96.0
		5	21.3	17.2	90.0	3.0	71.5	97.5
		6	21.1	18.6	80.0	2.7	63.6	97.5
		7	21.2	17.7	90.0	3.4	71.8	97.2
		8	22.1	13.4	80.0	3.2	63.8	97.1
Grand fir	S-39	5	21.9	14.3	90.0	7.6	74.2	94.0
		6	21.8	14.9	90.0	3.4	71.7	97.2
		7	21.9	13.9	90.0	6.1	73.3	95.1
		8	22.1	13.2	90.0	4.2	72.2	96.6
		13	21.4	17.1	80.0	5.7	65.3	94.9
		15	22.7	14.7	90.0	6.7	73.6	94.7
Incense cedar	S-36	3	21.9	14.4	80.0	3.7	64.2	96.6
		4	21.6	15.6	80.0	4.4	64.6	96.0

		5	21.8	14.7	80.0	3.7	64.2	96.6
		6	22.0	13.6	80.0	3.8	64.2	96.5
		7	22.0	13.9	90.0	4.9	72.6	96.0
Jack pine	L–105	1	35.8	39.8	90.0	2.4	71.2	98.0
		2	35.8	39.7	90.0	2.4	71.2	98.0
Loblolly pine	L–2	1	41.0	22.1	90.0	2.7	71.4	97.8
Lodgepole pine	S–469	1	22.2	12.6	90.0	3.4	71.7	97.2
		2	22.4	11.7	90.0	3.2	71.7	97.4
	S–499	4	21.8	14.7	90.0	4.9	72.6	96.0
		5	21.8	15.0	90.0	4.9	72.6	96.0
		7	22.2	12.9	80.0	3.2	63.9	97.1
		8	21.9	14.4	80.0	2.8	63.6	97.4
Longleaf pine	L–3	1	41.9	14.6	90.0	2.7	71.3	97.8
		2	41.9	14.6	90.0	2.4	71.2	98.0
		3	41.9	14.6	90.0	2.4	71.1	98.0
Red alder	S–524	4	21.8	14.7	80.0	4.4	64.5	96.0
		5	21.5	16.4	80.0	3.9	64.3	96.5
		8	22.0	13.8	80.0	2.1	63.2	98.0
		9	21.5	16.3	80.0	4.0	64.3	96.4
		10	21.4	16.8	80.0	4.0	64.3	96.4
		11	21.5	16.1	80.0	3.7	64.2	96.6
Red maple	S–14	2	22.3	12.1	80.0	4.4	64.4	96.0
		3	22.2	12.9	80.0	5.9	65.5	94.7
		4	22.2	12.9	80.0	8.1	66.8	92.8
Sycamore	S–18	1	22.0	13.6	80.0	4.2	64.4	96.2
		2	22.1	13.2	80.0	4.6	64.7	95.8
Tamarack	L–26E	18	40.8	10.4	90.0	2.7	71.4	97.8
		19	40.8	10.4	90.0	2.4	71.2	98.0
Tulip tree	S–16	4	21.7	15.5	80.0	4.6	64.7	95.8
		5	21.7	15.2	80.0	5.7	65.3	94.9
		6	22.0	13.7	89.1	5.4	72.2	95.6
Western hemlock	S–38	8	17.6	13.8	80.0	4.7	64.7	95.9
		9	20.1	14.4	80.0	7.4	66.3	93.6
White fir	S–35	4	11.8	9.3	87.2	2.3	69.0	98.0

TABLE 3.—*Record of experimental cooks using the soda process*—Continued.

Species.	Shipment number.	Cook number.	Cooking liquors at start of cook. Quantity per pound of chips, bone-dry weight. Total liquor.	NaOH.	Na_2CO_3.	Total Na_2O.	Duration of cooking. Total.	At zero gauge pressure.	At maximum gauge pressure.
			Gallons.	*Per cent.*	*Per cent.*	*Per cent.*	*Hours.*	*Hours.*	*Hours.*
Aspen	L–19	2	0.399	26.8	0.8	21.2	8.0	0.4	7.0
		4	.594	39.7	1.6	31.7	7.0	.2	6.0
		7	.376	22.4	.9	17.9	7.0	.2	6.0
		25	.429	25.0	.8	19.9	8.0	.4	7.0
Beech	S–7	5	.371	28.2	1.6	22.7	8.5	.3	8.0
		6	.370	27.8	2.0	22.7	8.3	.3	8.0
		7	.371	27.9	1.4	22.4	8.3	.3	8.0
		8	.362	30.2	1.8	24.4	8.3	.3	8.0
Cotton gum	S–4	3	.392	29.5	1.67	23.8	8.3	.3	8.0
		4	.405	30.3	2.7	25.2	8.3	.3	8.0
Douglas fir	S–498	1	.333	25.0	.7	19.8	8.0	.3	5.0
		2	.333	25.0	.7	19.8	7.0	.3	6.0
Engelmann spruce	S–502	4	.353	26.5	1.4	21.4	6.5	.3	6.0
		5	.384	28.8	1.0	22.9	6.3	.3	6.0
		6	.428	28.6	1.0	22.7	9.3	.3	9.0
		7	.441	33.1	1.3	26.3	9.5	.3	9.0
		8	.431	28.8	1.1	22.9	9.3	.3	9.0
Grand fir	S–39	5	.398	29.9	2.5	24.6	7.3	.3	7.0
		6	.400	30.0	1.1	23.9	9.3	.3	9.0
		7	.462	34.7	2.4	28.2	7.3	.3	7.0
		8	.462	34.7	1.6	27.8	9.3	.3	9.0
		13	.332	22.2	1.6	18.1	10.3	.3	10.0
		15	.349	26.2	1.9	21.4	8.3	.3	8.0
Incense cedar	S–36	3	.477	31.8	1.5	25.6	5.5	.3	5.0
		4	.481	32.1	1.8	25.9	6.5	.3	6.0

		5	.477	31.9	1.5	25.6	9.5	.3	9.0
		6	.326	21.8	1.0	17.4	12.3	.3	12.0
		7	.343	25.8	1.4	20.8	12.3	.3	12.0
Jack pine	L–105	1	.333	25.0	.7	19.8	7.0	.3	6.3
		2	.333	25.0	.7	19.8	8.0	.3	7.0
Loblolly pine	L–2	1	.333	25.0	.7	19.8	7.0	.3	6.0
Lodgepole pine	S–469	1	.390	29.4	1.1	23.3	9.3	.3	9.0
		2	.367	27.5	1.0	21.9	10.3	.3	10.0
	S–499	4	.368	27.6	1.5	22.3	7.5	.3	7.0
		5	.373	28.0	1.5	22.5	10.5	.3	10.0
		7	.442	29.5	1.2	23.6	10.3	.3	10.0
		8	.392	26.2	.9	20.8	12.3	.3	12.0
Longleaf pine	L–3	1	.333	25.0	.8	19.8	7.0	.5	6.0
		2	.266	20.0	.5	15.8	7.0	.3	6.0
		3	.267	20.0	.5	15.8	8.0	.3	7.0
Red alder	S–524	4	.388	25.9	1.4	20.9	8.3	.3	8.0
		5	.403	26.9	1.3	21.6	5.5	.3	5.0
		8	.520	34.7	.9	27.4	4.3	.3	4.3
		9	.534	35.6	1.8	28.6	6.3	.3	6.0
		10	.536	35.8	1.8	28.7	6.3	.3	6.0
		11	.681	45.4	2.1	36.5	6.3	.3	6.0
Red maple	S–14	2	.383	25.6	1.4	20.6	8.3	.3	8.0
		3	.386	25.8	1.9	21.1	10.3	.3	10.0
		4	.402	26.8	2.7	22.4	10.3	.3	10.0
Sycamore	S–18	1	.434	25.9	1.5	23.3	8.3	.3	8.0
		2	.387	25.9	1.5	20.8	10.3	.3	10.0
Tamarack	L–26E	18	.333	25.0	.8	19.9	7.0	.3	6.0
		19	.400	30.0	.8	23.8	7.0	.3	6.0
Tulip tree	S–16	4	.421	28.1	1.6	22.8	7.3	.3	7.0
		5	.427	28.5	2.0	23.3	10.3	.3	10.0
		6	.319	23.7	1.5	19.2	11.3	.3	11.0
Western hemlock	S–38	8	.385	25.7	1.5	20.8	8.3	.3	8.0
		9	.423	28.2	2.6	23.4	10.0	1.0	8.0
White fir	S–35	4	.346	25.2	.7	19.9	7.0	.3	6.0

TABLE 3.—*Record of experimental cooks using the soda process.*

Species.	Shipment number.	Cook number.	Chip charge, bone-dry weight.	Water in chips.	Cooking liquors at start of cook.			
					Concentrations.			Causticity.
					NaOH.	Na_2CO_3.	Total Na_2O.	
			Pounds.	*Per cent.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*	*Per cent.*
Aspen	L-19	2	39.4	9.1	80.5	2.2	63.7	97.9
		4	40.3	8.2	80.2	3.1	64.0	97.1
		7	39.9	9.8	71.6	2.7	57.1	97.2
		25	39.0	8.2	70.0	2.1	55.5	97.8
Beech	S-7	5	21.8	14.6	91.0	5.2	73.5	95.9
		6	22.1	13.0	90.0	6.4	73.5	94.9
		7	22.1	13.3	90.0	4.6	72.5	96.2
		8	21.9	14.2	100.0	5.8	80.9	95.8
Cotton gum	S-4	3	22.4	11.8	90.0	5.1	72.7	95.9
		4	22.1	13.0	90.0	8.1	74.5	93.6
Douglas fir	S-498	1	40.4	9.1	90.0	2.7	71.4	97.8
		2	40.4	9.1	90.0	2.4	71.2	98.0
Engelmann spruce	S-502	4	21.4	16.9	90.0	5.0	72.7	96.0
		5	21.3	17.2	90.0	3.0	71.5	97.5
		6	21.1	18.6	80.0	2.7	63.6	97.5
		7	21.2	17.7	90.0	3.4	71.8	97.2
		8	22.1	13.4	80.0	3.2	63.8	97.1
Grand fir	S-39	5	21.9	14.3	90.0	7.6	74.2	94.0
		6	21.8	14.9	90.0	3.4	71.7	97.2
		7	21.9	13.9	90.0	6.1	73.3	95.1
		8	22.1	13.2	90.0	4.2	72.2	96.6
		13	21.4	17.1	80.0	5.7	65.3	94.9
		15	22.7	14.7	90.0	6.7	73.6	94.7
Incense cedar	S-36	3	21.9	14.4	80.0	3.7	64.2	96.6
		4	21.6	15.6	80.0	4.4	64.6	96.0

		5	21.8	14.7	80.0	3.7	64.2	96.6
		6	22.0	13.6	80.0	3.8	64.2	96.5
		7	22.0	13.9	90.0	4.9	72.6	96.0
Jack pine	L–105	1	35.8	39.8	90.0	2.4	71.2	98.0
		2	35.8	39.7	90.0	2.4	71.2	98.0
Loblolly pine	L–2	1	41.0	22.1	90.0	2.7	71.4	97.8
Lodgepole pine	S–469	1	22.2	12.6	90.0	3.4	71.7	97.2
		2	22.4	11.7	90.0	3.2	71.7	97.4
	S–499	4	21.8	14.7	90.0	4.9	72.6	96.0
		5	21.8	15.0	90.0	4.9	72.6	96.0
		7	22.2	12.9	80.0	3.2	63.9	97.1
		8	21.9	14.4	90.0	2.8	63.6	97.4
Longleaf pine	L–3	1	41.9	14.6	90.0	2.7	71.3	97.8
		2	41.9	14.6	90.0	2.4	71.2	98.0
		3	41.9	14.6	90.0	2.4	71.1	98.0
Red alder	S–524	4	21.8	14.7	80.0	4.4	64.5	96.0
		5	21.5	16.4	80.0	3.9	64.3	96.5
		8	22.0	13.8	80.0	2.1	63.2	98.0
		9	21.5	16.3	80.0	4.0	64.3	96.4
		10	21.4	16.8	80.0	4.0	64.3	96.4
		11	21.5	16.1	80.0	3.7	64.2	96.6
Red maple	S–14	2	22.3	12.1	80.0	4.4	64.4	96.0
		3	22.2	12.9	80.0	5.9	65.5	94.7
		4	22.2	12.9	80.0	8.1	66.8	92.8
Sycamore	S–18	1	22.0	13.6	80.0	4.2	64.4	96.2
		2	22.1	13.2	80.0	4.6	64.7	95.8
Tamarack	L–26E	18	40.8	10.4	90.0	2.7	71.4	97.8
		19	40.8	10.4	90.0	2.4	71.2	98.0
Tulip tree	S–16	4	21.7	15.5	80.0	4.6	64.7	95.8
		5	21.7	15.2	80.0	5.7	65.3	94.9
		6	22.0	13.7	89.1	5.4	72.2	95.6
Western hemlock	S–38	8	17.6	13.8	80.0	4.7	64.7	95.9
		9	20.1	14.4	80.0	7.4	66.3	93.6
White fir	S–35	4	11.8	9.3	87.2	2.3	69.0	98.0

TABLE 3.—*Record of experimental cooks using the soda process*—Continued.

Species.	Shipment number.	Cook number.	Cooking liquors at start of cook.				Duration of cooking.		
			Quantity per pound of chips, bone-dry weight.				Total.	At zero gauge pressure.	At maximum gauge pressure.
			Total liquor.	NaOH.	Na_2CO_3.	Total Na_2O.			
			Gallons.	*Per cent.*	*Per cent.*	*Per cent.*	*Hours.*	*Hours.*	*Hours.*
Aspen	L–19	2	0.399	26.8	0.8	21.2	8.0	0.4	7.0
		4	.594	39.7	1.6	31.7	7.0	.2	6.0
		7	.376	22.4	.9	17.9	7.0	.2	6.0
		25	.429	25.0	.8	19.9	8.0	.4	7.0
Beech	S–7	5	.371	28.2	1.6	22.7	8.5	.3	8.0
		6	.370	27.8	2.0	22.7	8.3	.3	8.0
		7	.371	27.9	1.4	22.4	8.3	.3	8.0
		8	.362	30.2	1.8	24.4	8.3	.3	8.0
Cotton gum	S–4	3	.392	29.5	1.67	23.8	8.3	.3	8.0
		4	.405	30.3	2.7	25.2	8.3	.3	8.0
Douglas fir	S–498	1	.333	25.0	.7	19.8	8.0	.3	5.0
		2	.333	25.0	.7	19.8	7.0	.3	6.0
Engelmann spruce	S–502	4	.353	26.5	1.4	21.4	6.5	.3	6.0
		5	.384	28.8	1.0	22.9	6.3	.3	6.0
		6	.428	28.6	1.0	22.7	9.3	.3	9.0
		7	.441	33.1	1.3	26.3	9.5	.3	9.0
		8	.431	28.8	1.1	22.9	9.3	.3	9.0
Grand fir	S–39	5	.398	29.9	2.5	24.6	7.3	.3	7.0
		6	.400	30.0	1.1	23.9	9.3	.3	9.0
		7	.462	34.7	2.4	28.2	7.3	.3	7.0
		8	.462	34.7	1.6	27.8	9.3	.3	9.0
		13	.332	22.2	1.6	18.1	10.3	.3	10.0
		15	.349	26.2	1.9	21.4	8.3	.3	8.0
Incense cedar	S–36	3	.477	31.8	1.5	25.6	5.5	.3	5.0
		4	.481	32.1	1.8	25.9	6.5	.3	6.0

		5	.477	31.9	1.5	25.6	9.5	.3	9.0
		6	.326	21.8	1.0	17.4	12.3	.3	12.0
		7	.343	25.8	1.4	20.8	12.3	.3	12.0
Jack pine	L-105	1	.333	25.0	.7	19.8	7.0	.3	6.3
		2	.333	25.0	.7	19.8	8.0	.3	7.0
Loblolly pine	L-2	1	.333	25.0	.7	19.8	7.0	.3	6.0
Lodgepole pine	S-469	1	.390	29.4	1.1	23.3	9.3	.3	9.0
		2	.367	27.5	1.0	21.9	10.3	.3	10.0
	S-499	4	.368	27.6	1.5	22.3	7.5	.3	7.0
		5	.373	28.0	1.5	22.5	10.5	.3	10.0
		7	.442	29.5	1.2	23.6	10.3	.3	10.0
		8	.392	26.2	.9	20.8	12.3	.3	12.0
Longleaf pine	L-3	1	.333	25.0	.8	19.8	7.0	.5	6.0
		2	.266	20.0	.5	15.8	7.0	.3	6.0
		3	.267	20.0	.5	15.8	8.0	.3	7.0
Red alder	S-524	4	.388	25.9	1.4	20.9	8.3	.3	8.0
		5	.403	26.9	1.3	21.6	5.5	.3	5.0
		8	.520	34.7	.9	27.4	4.3	.3	4.3
		9	.534	35.6	1.8	28.6	6.3	.3	6.0
		10	.536	35.8	1.8	28.7	6.3	.3	6.0
		11	.681	45.4	2.1	36.5	6.3	.3	6.0
Red maple	S-14	2	.383	25.6	1.4	20.6	8.3	.3	8.0
		3	.386	25.8	1.9	21.1	10.3	.3	10.0
		4	.402	26.8	2.7	22.4	10.3	.3	10.0
Sycamore	S-18	1	.434	25.9	1.5	23.3	8.3	.3	8.0
		2	.387	25.9	1.5	20.8	10.3	.3	10.0
Tamarack	L-26E	18	.333	25.0	.8	19.9	7.0	.3	6.0
		19	.400	30.0	.8	23.8	7.0	.3	6.0
Tulip tree	S-16	4	.421	28.1	1.6	22.8	7.3	.3	7.0
		5	.427	28.5	2.0	23.3	10.3	.3	10.0
		6	.319	23.7	1.5	19.2	11.3	.3	11.0
Western hemlock	S-38	8	.385	25.7	1.5	20.8	8.3	.3	8.0
		9	.423	28.2	2.6	23.4	10.0	1.0	8.0
White fir	S-35	4	.346	25.2	.7	19.9	7.0	.3	6.0

TABLE 3.—*Record of experimental cooks using the soda process*—Continued.

Species.	Shipment number.	Cook number.	Maximum gauge pressure.	Yields.		Quality of pulps.		
				Screened pulp.	Screenings.	Ash.	Bleach required.	Loss on bleaching.
			Pounds per square inch.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Aspen	L-19	2	100	50.3	0.0	0.81	8.0	1.1
		4	98	46.5	.0	.95	6.0	.4
		7	100	52.6	.0	.85	9.0	1.6
		25	100	50.8	.0	.79	9.5	1.4
Beech	S-7	5	110	50.7	.1	.73	13.2	2.1
		6	110	44.7	.2	.76	15.3	1.8
		7	110	45.4	.8	.78	14.7	3.0
		8	110	39.8	1.0	.92	.....	.....
Cotton gum	S-4	3	110	.....	.....	1.51	23.2	1.5
		4	110	43.7	.1	1.73	26.5	1.7
Douglas fir	S-498	1	110	45.3	.1	.....	.....	.....
		2	100	46.1	.0	.....	.....	.....
Engelmann spruce	S-502	4	110	46.0	1.0	.71	93.0	.....
		5	110	37.8	.9	.82	67.0	7.4
		6	110	39.4	1.0	.69	69.0	8.2
		7	110	36.2	.1	.71	42.5	4.9
		8	110	42.4	.4	.....	.....	.....
Grand fir	S-39	5	110	41.7	.1	.52	63.0	6.1
		6	110	41.5	.1	.60	46.0	4.8
		7	110	41.6	.1	.66	47.5	8.9
		8	110	40.8	.1	.59	44.6	4.4
		13	110	46.0	3.7	.....	.....	.....
		15	110	47.9	.5	.....	.....	.....
Incense cedar	S-36	3	100	38.6	1.3	.96	.....	.....
		4	110	39.5	.2	.78	90.0	.....
		5	110	35.2	.1	.73	80.0	9.1
		6	110	41.7	3.3	1.05	.....	.....
		7	110	36.3	.2	.69	.....	.....

Jack pine	L–105	1	100	48.1	.0			
		2	90	51.8	.1			
Loblolly pine	L–2	1	110	45.4	.0			
Lodgepole pine	S–469	1	110	38.1	.1	.64	41.0	4.6
		2	110	40.9	.1	.90	51.5	
	S–499	4	110	44.4	.1	.82	46.0	5.4
		5	110	39.0	.2	.87	41.0	5.4
		7	110	40.4	.1	.73	46.5	5.5
		8	110	42.1	1.1			
Longleaf pine	L–3	1	100	48.6	.0			
		2	100	46.7	4.4			
		3	100	50.4	.0			
Red alder	S–524	4	110	45.4	.1	.76	23.8	3.2
		5	110	48.7	.1	.77	25.5	3.5
		8	110	42.7	.1	.69	20.8	2.5
		9	110	38.2	.1	.71	20.1	2.8
		10	110	41.1	.1	.66	18.5	2.8
		11	110	39.1	.1	.87	18.0	2.3
Red maple	S–14	2	110	44.6	.2	.91	15.5	2.6
		3	110			.63	13.0	
		4	110	42.6	.3	.78	12.4	
Sycamore	S–18	1	110	43.4	.1	1.08	13.7	3.2
		2	110	45.4	.2	1.27	15.0	
Tamarack	L–26E	18	110	35.0	8.7			
		19	110	37.8	.0			
Tulip tree	S–16	4	110	42.2	.0	.85	15.0	3.0
		5	110	40.7	.1	1.01	14.1	2.4
		6	110	40.5	.1	.98	18.8	3.1
Western hemlock	S–38	8	110	45.7	.8			
		9	110	42.6	1.0		66.4	
White fir	S–35	4	100	49.0	4.7			

INDEX TO PULP SPECIMENS.

Table 4 is an index to the specimens of bleached and unbleached soda and sulphite pulps which follow. The botanical names corresponding to the common names given here can be found in Table 1. By means of the shipment numbers and cook numbers reference may be made to Tables 2 and 3, which show the cooking conditions and other data for the pulps used in making the specimens.

TABLE 4.—*Index to pulp specimens.*

Specimen No.	Species.	Shipment No.	Cook No.	Kind.	Condition.
	Broad-leaved woods or hardwoods.				
1	Aspen	L–19	2	Soda	Natural color.
2	do	L–19	4	do	Bleached.
3	Beech	S–7	7, 8	do	Natural color.
4	do	S–7	5, 6, 8	do	Bleached.
5	Cotton gum	S–2	1, 4	Sulphite	Natural color.
6	do	S–2	2	do	Bleached.
7	do	S–4	3, 4	Soda	Natural color.
8	Red alder	S–524	10, 11	do	Do.
9	do	S–524	8, 9	do	Bleached.
10	Red maple	S–14	2, 3	do	Natural color.
11	Sycamore	S–18	1, 2	do	Do.
12	Tulip tree	S–16	5, 6	do	Do.
13	do	S–16	4, 5, 6	do	Bleached.
	Conifers or softwoods.				
14	Bald cypress	S–3	1, 2	Sulphite	Natural color.
15	Douglas fir	S–498	1, 2	do	Do.
16	do	S–498	6	Soda	Do.
17	Engelmann spruce	S–502	1, 2, 4, 5	Sulphite	Do.
18	do	S–22, 25, 28 S–502	1, 2, 4 3, 6, 12	do	Bleached.
19	do	S–502	5, 7	Soda	Natural color.
20	do	S–502	5, 6, 8	do	Bleached.
21	Grand fir	S–39	4, 5	Sulphite	Natural color.
22	do	S–39	1, 2, 3	do	Bleached.

TABLE 4.—*Index to pulp specimens*—Continued.

Specimen No.	Species.	Shipment No.	Cook No.	Kind.	Condition.
	Conifers or softwoods—Continued.				
23	Grand fir	S–39	7, 8	Soda	Natural color.
24	do	S–39	5, 6	do	Bleached.
25	Hemlock	S–8	1, 2	do	Natural color.
26	Incense cedar	S–36	1, 2, 3	Sulphite	Do.
27	do	S–36	4, 5	Soda	Do.
28	do	S–36	3, 4, 5, 7	do	Bleached.
29	Jack pine	L–26B	7, 8, 9	Sulphite	Natural color.
30	do	L–105	2	Soda	Do.
31	do	L–105	1, 2	do	Bleached.
32	Loblolly pine	S–5	3	Sulphite	Natural color.
		S–33	1, 2, 3		
33	do	S–5	1, 2	do	Bleached.
		S–33	4		
34	do	L–2	1	Soda	Natural color.
35	do	L–2	1	do	Bleached.
36	Lodgepole pine	S–499	1, 2, 9	Sulphite	Natural color.
37	do	S–32	2	do	Bleached.
		S–499	3, 6, 8		
38	do	S–499	4, 5	Soda	Natural color.
39	do	S–469	1	do	Bleached.
		S–499	4		
40	Longleaf pine	L–3	1	do	Natural color.
41	do	L–3	1, 3	do	Bleached.
42	Red spruce	S–11	4, 5	Sulphite	Natural color.
43	do	S–310	1–12	do	Bleached.
44	Scrub pine	S–19, 21	2	do	Natural color.
		S–20	3		
45	do	S–19, 21	1, 3	do	Bleached.
		S–20	2		
46	Tamarack	L–26E	14, 15	do	Natural color.
47	do	L–26E	13	do	Bleached.
		L–65–1	53		
48	do	L–26E	18	Soda	Natural color.
49	do	L–26E	19	do	Bleached.
50	Western hemlock	S–38	5	Sulphite	Natural color.
51	do	S–38	1–5	do	Bleached.
52	do	S–38	8, 9	Soda	Natural color.
53	White fir	S–35	1, 2	Sulphite	Do.
		S–35, 37	4, 5		
54	do	S–35, 37	1, 8	do	Bleached.
55	do	S–35	4	Soda	Natural color.

TABLE 2.—*Record of experimental cooks using the sulphite process*—Continued.

Species.	Shipment number.	Cook number.	Yields.		Quality of pulps.			
			Screened pulp.	Screenings.	Ash.	Cellulose.	Bleach required.	Loss on bleaching.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bald cypress	S–3	1	43.5	[1] 3.9	1.18	72.0	.....	.....
		2	46.9	[1] 2.4	.68	75.6	126.0	12.9
		3	.....	[1] .5	.52	81.5	52.0	3.8
Cotton gum	S–2	1	43.0	[1] 1.8	.99	83.5	35.0	4.6
		2	42.6	[1] .3	.78	83.6	17.0	2.1
		3	44.5	[1] .9	1.13	81.5	20.5	3.3
		4	43.5	[1] .4	.99	82.7	35.0	5.2
Douglas fir	S–498	1	38.8	16.0	1.25	.....	70.0	11.9
		2	32.9	25.8	.....	.....	.....	.....
Engelmann spruce	S–502	1	34.7	1.9	.89	86.7	15.0	2.9
		2	39.0	.3	.75	87.2	13.5	2.5
		3	45.2	1.2	.89	85.7	22.5	5.1
		4	45.7	.5	1.12	87.7	12.0	2.4
		5	52.5	.5	.98	88.0	12.3	2.2
		6	40.0	.3	.86	85.9	12.5	2.3
		12	40.1	.5	1.35	85.6	21.0	5.1
Grand fir	S–39	1	51.4	1.7	1.71	.....	80.0	12.8
		2	24.1	19.4	2.00	72.8	.....	.....
		3	46.0	.6	.76	.....	26.6	1.6
		4	46.9	1.5	.86	.....	28.0	5.7
		5	46.4	2.4	2.78	.....	40.0	7.8
Hemlock	S–8	1	43.8	[1] 1.5	.75	81.2	85.0	10.0
		2	39.2	[1] 3.7	.38	85.8	37.0	4.9
Incense cedar	S–36	1	40.8	8.3	2.37	71.3	.....	.....
		2	37.9	1.3	1.38	78.6	.....	.....
		3	16.3	.4	1.35	80.8	.....	.....
Jack pine	L–26B	6	45.5	4.9	.....	.....	.....	.....
		7	34.8	17.2	.....	.....	.....	.....

		8	40.7	5.9				
		9	53.2	3.0				
Loblolly pine	S–5	1		[1].3	.83	85.4	35.0	7.7
		3		[1]2.1	.57	83.1	39.0	5.7
	S–33	1			4.50			
		2			1.06	76.6	72.0	9.3
		3			1.45		80.0	12.9
Lodgepole pine	S–499	1	43.6	7.6	1.15	80.3	50.0	8.8
		2	43.1	2.4	1.29	81.6	39.0	7.0
		3	39.9	3.1	2.53	81.2	29.0	6.6
		6	36.8	.5	.60	78.5	22.8	3.8
		7	50.9	5.3	6.84	75.5	43.0	13.7
		8	32.4	5.7	.65		23.0	3.6
		9	33.5	.3	.44		16.8	2.5
Red spruce	S–11	2						
		3		[1]8.2	1.96	73.5	98.0	22.0
		4		[1].7	.67	86.1	17.0	3.6
		5	53.9	1.7	2.00	84.4	35.0	6.3
Scrub pine	S–19, 21	1		[1]6.7	1.13		65.0	9.5
		2		[1]3.1	.59		67.0	7.0
		3		[1]1.1	.43		20.4	4.1
Tamarack	L–26E	14	42.8	8.4				
		15	46.0	.8				
		16	45.8	1.5				
		17	46.7	1.7				
Western hemlock	S–38	1	43.6	.8	2.41	85.1	44.8	7.7
		2	45.2	2.5	1.29	83.1	41.0	7.6
		3	47.3	1.1	1.13	84.7	35.0	6.4
		4	28.6	18.1	1.24	80.3	72.0	11.7
		5	42.0	.3	.66	85.9	25.0	4.5
White fir	S–35	1	40.6	1.3	1.03	85.8	20.5	4.0
		2	42.7	.9	1.22	85.1	23.5	4.7
	S–35, 37	1	45.5	.2	1.23	85.6	28.0	4.9
		4	48.3	.8	.66	88.0	19.0	1.8
		5	44.8	.4	.90	83.8	17.0	3.2
		8	41.4	.7	.43	86.0	12.8	1.1

[1] Air-dry screenings. Percentage based on bone-dry weight of chips.

TABLE 3.—*Record of experimental cooks using the soda process.*

Species.	Shipment number.	Cook number.	Chip charge, bone-dry weight.	Water in chips.	Cooking liquors at start of cook.			
					Concentrations.			Causticity.
					NaOH.	Na_2CO_3.	Total Na_2O.	
			Pounds.	*Per cent.*	*Grams per liter.*	*Grams per liter.*	*Grams per liter.*	*Per cent.*
Aspen	L–19	2	39.4	9.1	80.5	2.2	63.7	97.9
		4	40.3	8.2	80.2	3.1	64.0	97.1
		7	39.9	9.8	71.6	2.7	57.1	97.2
		25	39.0	8.2	70.0	2.1	55.5	97.8
Beech	S–7	5	21.8	14.6	91.0	5.2	73.5	95.9
		6	22.1	13.0	90.0	6.4	73.5	94.9
		7	22.1	13.3	90.0	4.6	72.5	96.2
		8	21.9	14.2	100.0	5.8	80.9	95.8
Cotton gum	S–4	3	22.4	11.8	90.0	5.1	72.7	95.9
		4	22.1	13.0	90.0	8.1	74.5	93.6
Douglas fir	S–498	1	40.4	9.1	90.0	2.7	71.4	97.8
Engelmann spruce	S–502	2	40.4	9.1	90.0	2.4	71.2	98.0
		4	21.4	16.9	90.0	5.0	72.7	96.0
		5	21.3	17.2	90.0	3.0	71.5	97.5
		6	21.1	18.6	80.0	2.7	63.6	97.5
		7	21.2	17.7	90.0	3.4	71.8	97.2
		8	22.1	13.4	80.0	3.2	63.8	97.1
Grand fir	S–39	5	21.9	14.3	90.0	7.6	74.2	94.0
		6	21.8	14.9	90.0	3.4	71.7	97.2
		7	21.9	13.9	90.0	6.1	73.3	95.1
		8	22.1	13.2	90.0	4.2	72.2	96.6
		13	21.4	17.1	80.0	5.7	65.3	94.9
		15	22.7	14.7	90.0	6.7	73.6	94.7
Incense cedar	S–36	3	21.9	14.4	80.0	3.7	64.2	96.6
		4	21.6	15.6	80.0	4.4	64.6	96.0

		5	21.8	14.7	80.0	3.7	64.2	96.6
		6	22.0	13.6	80.0	3.8	64.2	96.5
		7	22.0	13.9	90.0	4.9	72.6	96.0
Jack pine	L–105	1	35.8	39.8	90.0	2.4	71.2	98.0
		2	35.8	39.7	90.0	2.4	71.2	98.0
Loblolly pine	L–2	1	41.0	22.1	90.0	2.7	71.4	97.8
Lodgepole pine	S–469	1	22.2	12.6	90.0	3.4	71.7	97.2
		2	22.4	11.7	90.0	3.2	71.7	97.4
	S–499	4	21.8	14.7	90.0	4.9	72.6	96.0
		5	21.8	15.0	90.0	4.9	72.6	96.0
		7	22.2	12.9	80.0	3.2	63.9	97.1
		8	21.9	14.4	90.0	2.8	63.6	97.4
Longleaf pine	L–3	1	41.9	14.6	90.0	2.7	71.3	97.8
		2	41.9	14.6	90.0	2.4	71.2	98.0
		3	41.9	14.6	90.0	2.4	71.1	98.0
Red alder	S–524	4	21.8	14.7	80.0	4.4	64.5	96.0
		5	21.5	16.4	80.0	3.9	64.3	96.5
		8	22.0	13.8	80.0	2.1	63.2	98.0
		9	21.5	16.3	80.0	4.0	64.3	96.4
		10	21.4	16.8	80.0	4.0	64.3	96.4
		11	21.5	16.1	80.0	3.7	64.2	96.6
Red maple	S–14	2	22.3	12.1	80.0	4.4	64.4	96.0
		3	22.2	12.9	80.0	5.9	65.5	94.7
		4	22.2	12.9	80.0	8.1	66.8	92.8
Sycamore	S–18	1	22.0	13.6	80.0	4.2	64.4	96.2
		2	22.1	13.2	80.0	4.6	64.7	95.8
Tamarack	L–26E	18	40.8	10.4	90.0	2.7	71.4	97.8
		19	40.8	10.4	90.0	2.4	71.2	98.0
Tulip tree	S–16	4	21.7	15.5	80.0	4.6	64.7	95.8
		5	21.7	15.2	80.0	5.7	65.3	94.9
		6	22.0	13.7	89.1	5.4	72.2	95.6
Western hemlock	S–38	8	17.6	13.8	80.0	4.7	64.7	95.9
		9	20.1	14.4	80.0	7.4	66.3	93.6
White fir	S–35	4	11.8	9.3	87.2	2.3	69.0	98.0

TABLE 3.—*Record of experimental cooks using the soda process*—Continued.

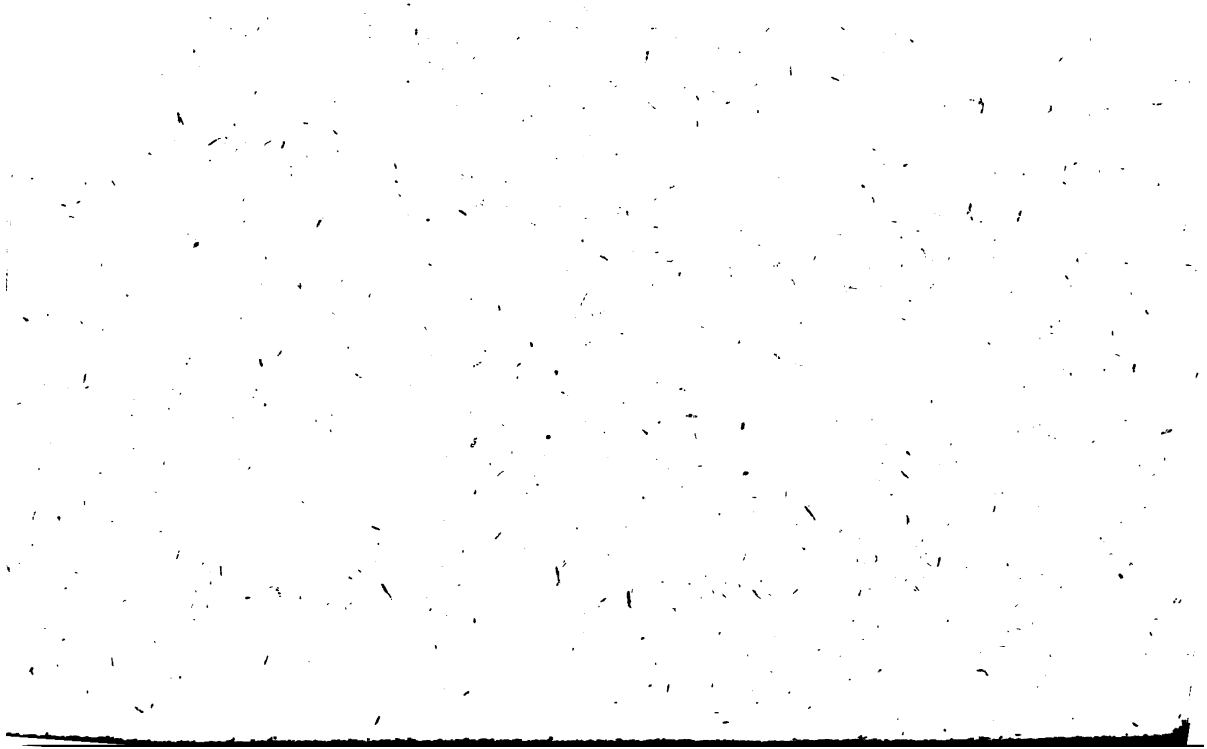
Species.	Shipment number.	Cook number.	Cooking liquors at start of cook. Quantity per pound of chips, bone-dry weight. Total liquor.	NaOH.	Na_2CO_3.	Total Na_2O.	Duration of cooking. Total.	At zero gauge pressure.	At maximum gauge pressure.
			Gallons.	*Per cent.*	*Per cent.*	*Per cent.*	*Hours.*	*Hours.*	*Hours.*
Aspen	L–19	2	0.399	26.8	0.8	21.2	8.0	0.4	7.0
		4	.594	39.7	1.6	31.7	7.0	.2	6.0
		7	.376	22.4	.9	17.9	7.0	.2	6.0
		25	.429	25.0	.8	19.9	8.0	.4	7.0
Beech	S–7	5	.371	28.2	1.6	22.7	8.5	.3	8.0
		6	.370	27.8	2.0	22.7	8.3	.3	8.0
		7	.371	27.9	1.4	22.4	8.3	.3	8.0
		8	.362	30.2	1.8	24.4	8.3	.3	8.0
Cotton gum	S–4	3	.392	29.5	1.67	23.8	8.3	.3	8.0
		4	.405	30.3	2.7	25.2	8.3	.3	8.0
Douglas fir	S–498	1	.333	25.0	.7	19.8	8.0	.3	5.0
		2	.333	25.0	.7	19.8	7.0	.3	6.0
Engelmann spruce	S–502	4	.353	26.5	1.4	21.4	6.5	.3	6.0
		5	.384	28.8	1.0	22.9	6.3	.3	6.0
		6	.428	28.6	1.0	22.7	9.3	.3	9.0
		7	.441	33.1	1.3	26.3	9.5	.3	9.0
		8	.431	28.8	1.1	22.9	9.3	.3	9.0
Grand fir	S–39	5	.398	29.9	2.5	24.6	7.3	.3	7.0
		6	.400	30.0	1.1	23.9	9.3	.3	9.0
		7	.462	34.7	2.4	28.2	7.3	.3	7.0
		8	.462	34.7	1.6	27.8	9.3	.3	9.0
		13	.332	22.2	1.6	18.1	10.3	.3	10.0
		15	.349	26.2	1.9	21.4	8.3	.3	8.0
Incense cedar	S–36	3	.477	31.8	1.5	25.6	5.5	.3	5.0
		4	.481	32.1	1.8	25.9	6.5	.3	6.0

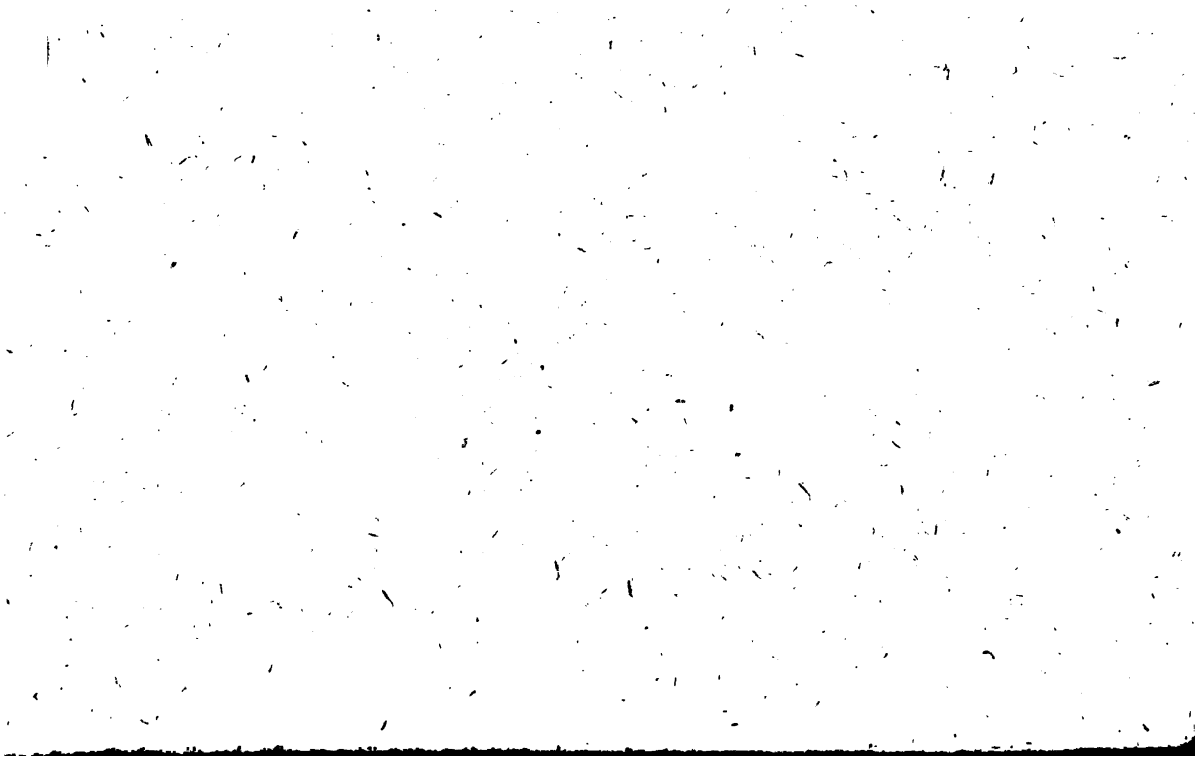
		5	.477	31.9	1.5	25.6	9.5	.3	9.0
		6	.326	21.8	1.0	17.4	12.3	.3	12.0
		7	.343	25.8	1.4	20.8	12.3	.3	12.0
Jack pine	L-105	1	.333	25.0	.7	19.8	7.0	.3	6.3
		2	.333	25.0	.7	19.8	8.0	.3	7.0
Loblolly pine	L-2	1	.333	25.0	.7	19.8	7.0	.3	6.0
Lodgepole pine	S-469	1	.390	29.4	1.1	23.3	9.3	.3	9.0
		2	.367	27.5	1.0	21.9	10.3	.3	10.0
	S-499	4	.368	27.6	1.5	22.3	7.5	.3	7.0
		5	.373	28.0	1.5	22.5	10.5	.3	10.0
		7	.442	29.5	1.2	23.6	10.3	.3	10.0
		8	.392	26.2	.9	20.8	12.3	.3	12.0
Longleaf pine	L-3	1	.333	25.0	.8	19.8	7.0	.5	6.0
		2	.266	20.0	.5	15.8	7.0	.3	6.0
		3	.267	20.0	.5	15.8	8.0	.3	7.0
Red alder	S-524	4	.388	25.9	1.4	20.9	8.3	.3	8.0
		5	.403	26.9	1.3	21.6	5.5	.3	5.0
		8	.520	34.7	.9	27.4	4.3	.3	4.3
		9	.534	35.6	1.8	28.6	6.3	.3	6.0
		10	.536	35.8	1.8	28.7	6.3	.3	6.0
		11	.681	45.4	2.1	36.5	6.3	.3	6.0
Red maple	S-14	2	.383	25.6	1.4	20.6	8.3	.3	8.0
		3	.386	25.8	1.9	21.1	10.3	.3	10.0
		4	.402	26.8	2.7	22.4	10.3	.3	10.0
Sycamore	S-18	1	.434	25.9	1.5	23.3	8.3	.3	8.0
		2	.387	25.9	1.5	20.8	10.3	.3	10.0
Tamarack	L-26E	18	.333	25.0	.8	19.9	7.0	.3	6.0
		19	.400	30.0	.8	23.8	7.0	.3	6.0
Tulip tree	S-16	4	.421	28.1	1.6	22.8	7.3	.3	7.0
		5	.427	28.5	2.0	23.3	10.3	.3	10.0
		6	.319	23.7	1.5	19.2	11.3	.3	11.0
Western hemlock	S-38	8	.385	25.7	1.5	20.8	8.3	.3	8.0
		9	.423	28.2	2.6	23.4	10.0	1.0	8.0
White fir	S-35	4	.346	25.2	.7	19.9	7.0	.3	6.0

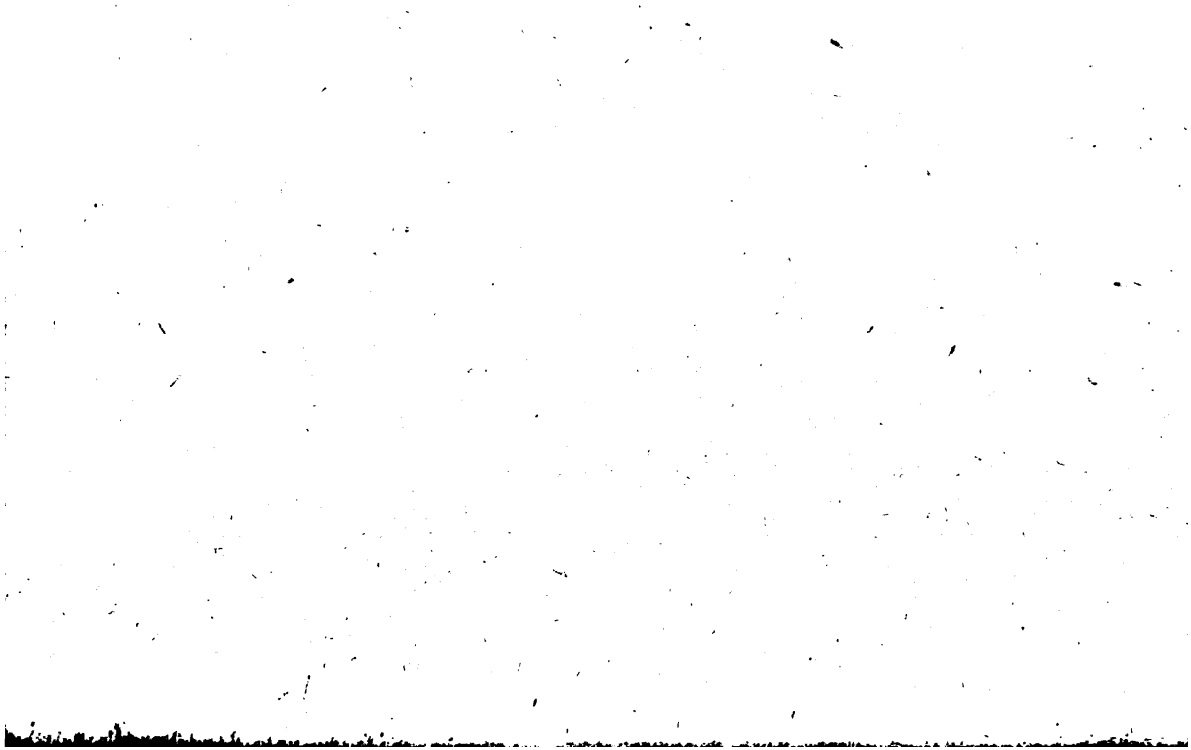
TABLE 3.—*Record of experimental cooks using the soda process*—Continued.

Species.	Shipment number.	Cook number.	Maximum gauge pressure.	Yields.		Quality of pulps.		
				Screened pulp.	Screenings.	Ash.	Bleach required.	Loss on bleaching.
			Pounds per square inch.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Aspen	L-19	2	100	50.3	0.0	0.81	8.0	1.1
		4	98	46.5	.0	.95	6.0	.4
		7	100	52.6	.0	.85	9.0	1.6
		25	100	50.8	.0	.79	9.5	1.4
Beech	S-7	5	110	50.7	.1	.73	13.2	2.1
		6	110	44.7	.2	.76	15.3	1.8
		7	110	45.4	.8	.78	14.7	3.0
		8	110	39.8	1.0	.92	.....	.....
Cotton gum	S-4	3	110	.....	.....	1.51	23.2	1.5
		4	110	43.7	.1	1.73	26.5	1.7
Douglas fir	S-498	1	110	45.3	.1	.....	.....	.....
		2	100	46.1	.0	.....	.....	.....
Engelmann spruce	S-502	4	110	46.0	1.0	.71	93.0	.....
		5	110	37.8	.9	.82	67.0	7.4
		6	110	39.4	1.0	.69	69.0	8.2
		7	110	36.2	.1	.71	42.5	4.9
		8	110	42.4	.4	.....	.....	.....
Grand fir	S-39	5	110	41.7	.1	.52	63.0	6.1
		6	110	41.5	.1	.60	46.0	4.8
		7	110	41.6	.1	.66	47.5	8.9
		8	110	40.8	.1	.59	44.6	4.4
		13	110	46.0	3.7	.....	.....	.....
		15	110	47.9	.5	.....	.....	.....
Incense cedar	S-36	3	100	38.6	1.3	.96	.....	.....
		4	110	39.5	.2	.78	90.0	.....
		5	110	35.2	.1	.73	80.0	9.1
		6	110	41.7	3.3	1.05	.....	.....
		7	110	36.3	.2	.69	.....	.....

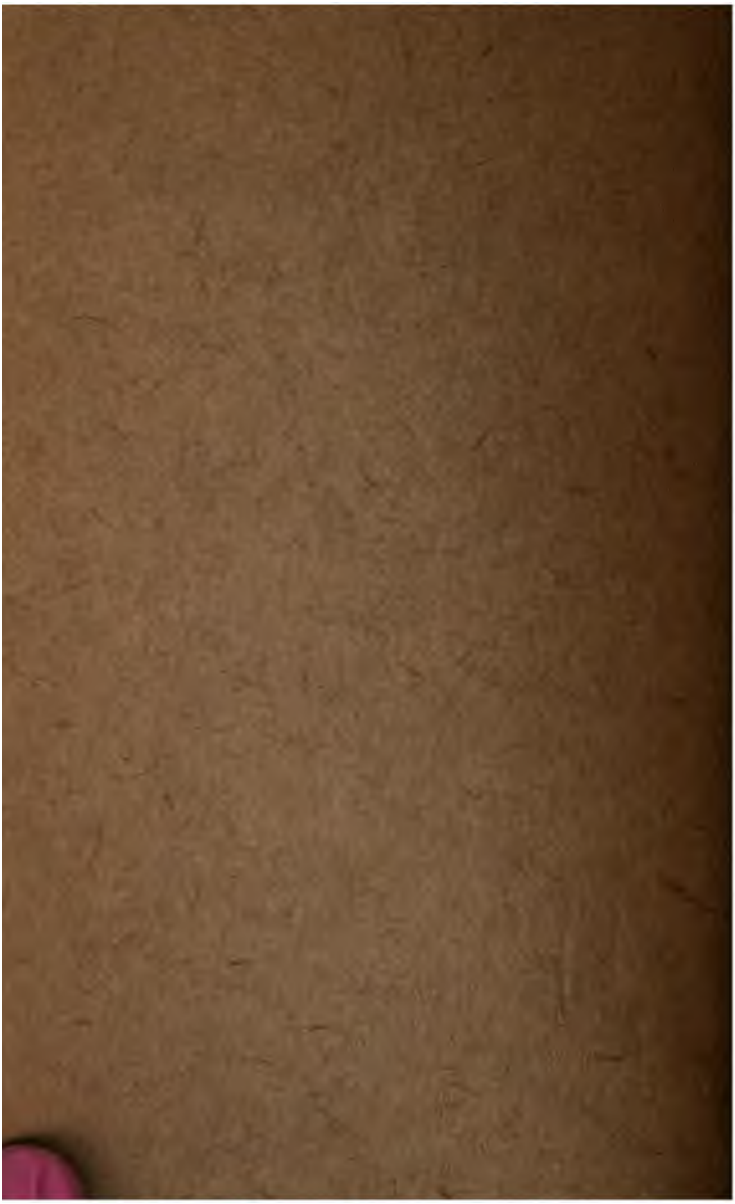
Jack pine	L–105	1	100	48.1	.0			
		2	90	51.8	.1			
Loblolly pine	L–2	1	110	45.4	.0			
Lodgepole pine	S–469	1	110	38.1	.1	.64	41.0	4.6
		2	110	40.9	.1	.90	51.5	
	S–499	4	110	44.4	.1	.82	46.0	5.4
		5	110	39.0	.2	.87	41.0	5.4
		7	110	40.4	.1	.73	46.5	5.5
		8	110	42.1	1.1			
Longleaf pine	L–3	1	100	48.6	.0			
		2	100	46.7	4.4			
		3	100	50.4	.0			
Red alder	S–524	4	110	45.4	.1	.76	23.8	3.2
		5	110	48.7	.1	.77	25.5	3.5
		8	110	42.7	.1	.69	20.8	2.5
		9	110	38.2	.1	.71	20.1	2.8
		10	110	41.1	.1	.66	18.5	2.8
		11	110	39.1	.1	.87	18.0	2.3
Red maple	S–14	2	110	44.6	.2	.91	15.5	2.6
		3	110			.63	13.0	
		4	110	42.6	.3	.78	12.4	
Sycamore	S–18	1	110	43.4	.1	1.08	13.7	3.2
		2	110	45.4	.2	1.27	15.0	
Tamarack	L–26E	18	110	35.0	8.7			
		19	110	37.8	.0			
Tulip tree	S–16	4	110	42.2	.0	.85	15.0	3.0
		5	110	40.7	.1	1.01	14.1	2.4
		6	110	40.5	.1	.98	18.8	3.1
Western hemlock	S–38	8	110	45.7	.8			
		9	110	42.6	1.0		66.4	
White fir	S–35	4	100	49.0	4.7			

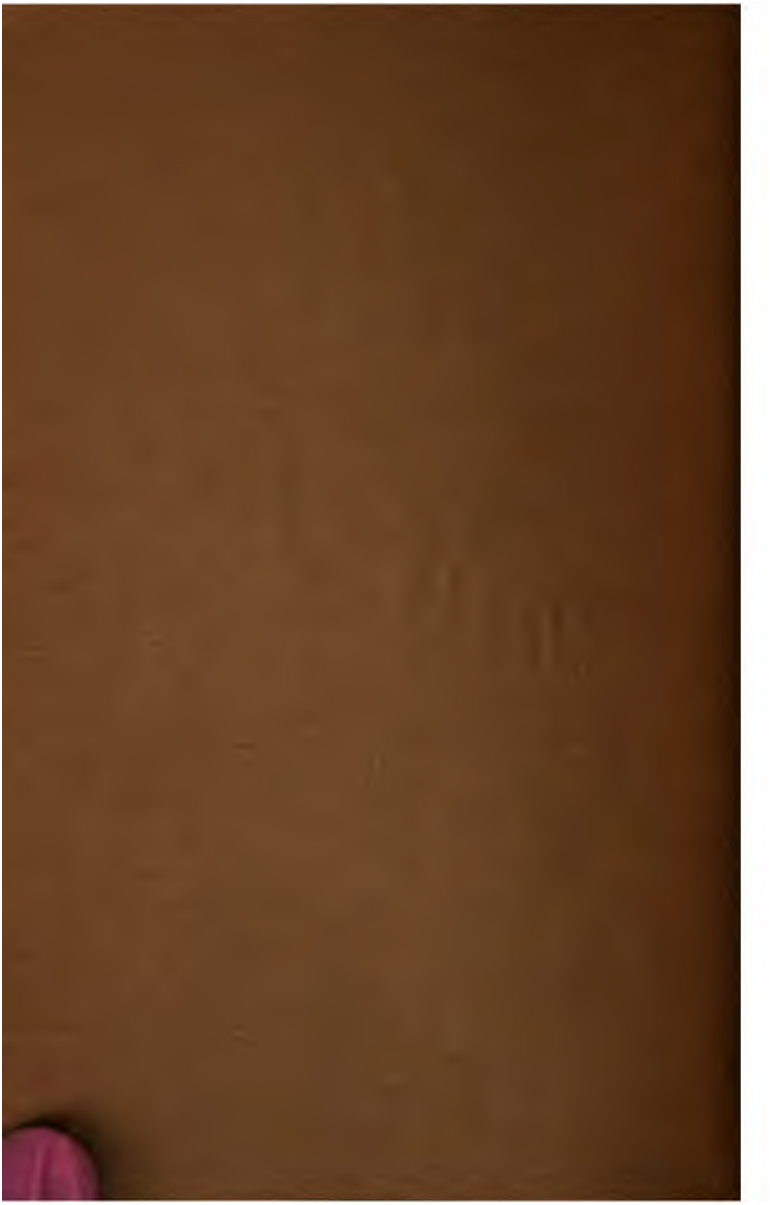


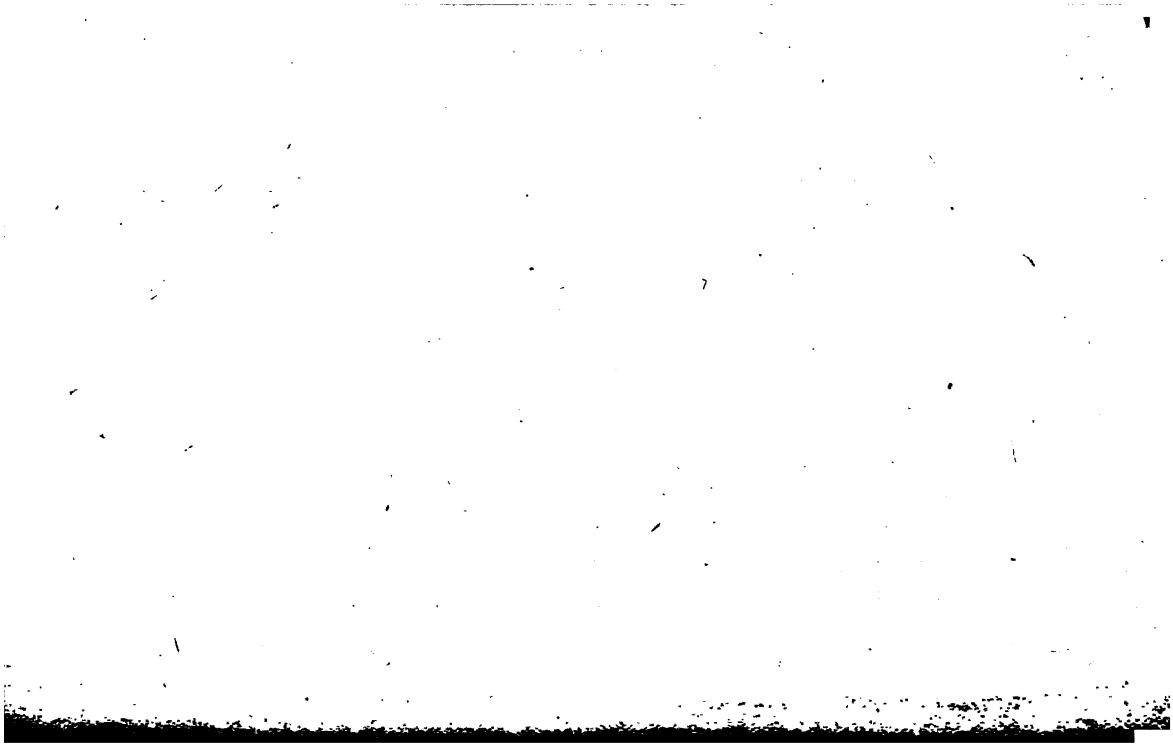


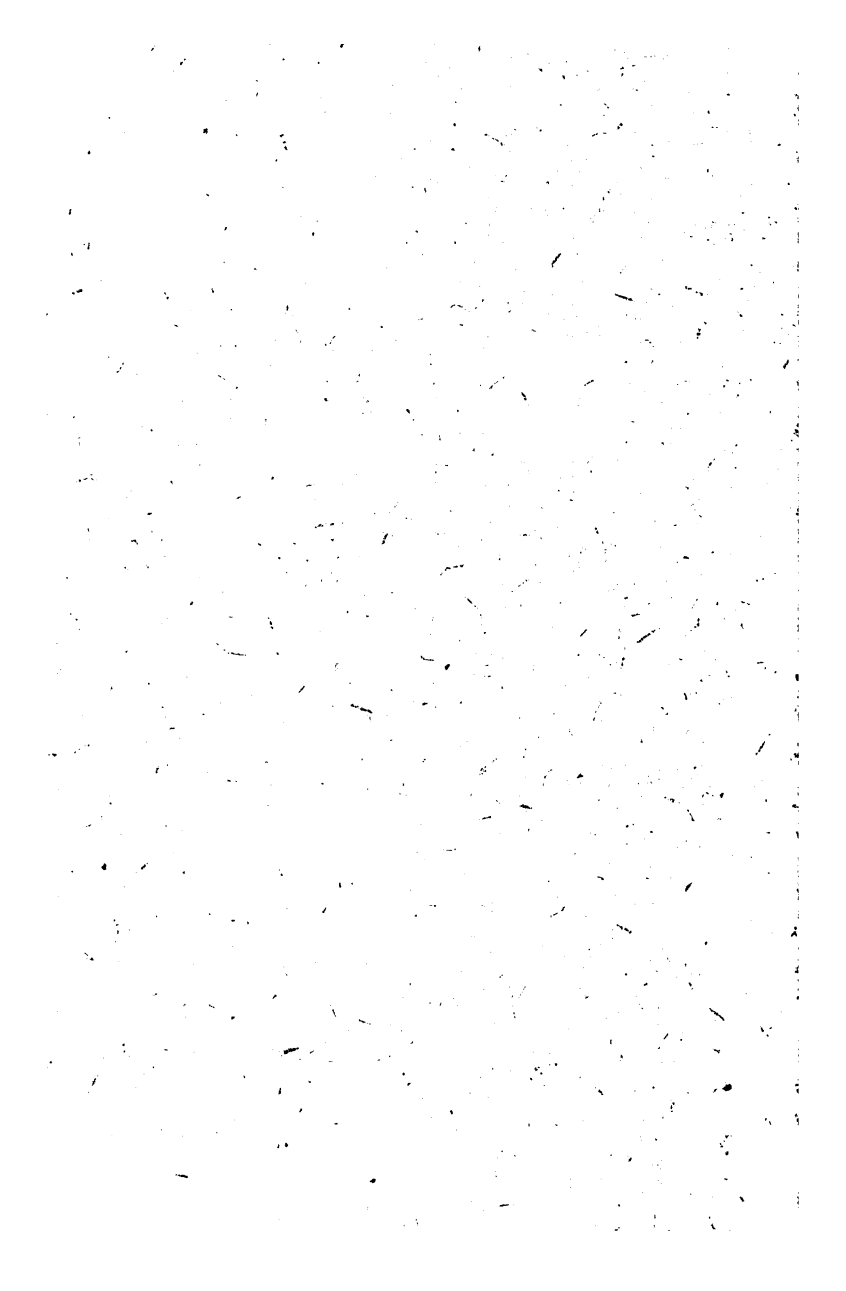


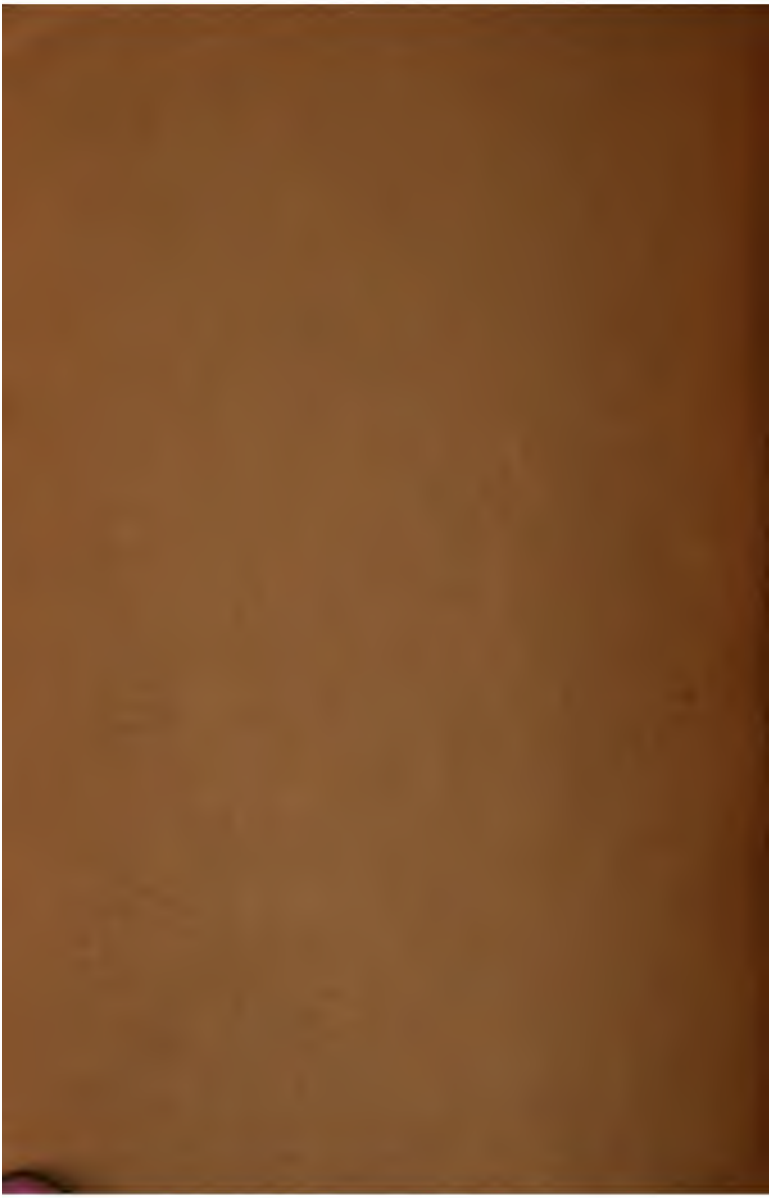
16











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